DELIVERY SYSTEM AND METHOD OF REAL-TIME MULTIMEDIA STREAMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to delivery techniques of real-time data streams and in particular to system and method

5 of delivering real-time data streams over a network.

2. Description of the Related Art

In general, a video transmission system may be divided into three main types of infrastructure: Television broadcasting such as Broadcasting Satellite (BS) or

10 Communication Satellite (CS); Cable Television (CATV) broadcasting; and Internet broadcasting. A recent shift from analog-base to digital-base makes a wide variety of hitherto impossible services possible. In the field of Television broadcasting, for example, the following services become

15 feasible:

- Several hundred high-quality channels for providing programs;

- EPG (Electronic Programming Guide);

- Program reservations and watching using a home server;

20 - Program-synchronization broadcasting such that, for example, a WWW homepage is synchronized to a program, which is realized in analog broadcasting systems such as ADAMS (TV-Asahi Data

and Multimedia Service) or BitCast; and

● Audience participation live program through Interactive (bidirectional) broadcasting.

In addition, there has been proposed a system such as
5   Real Video G2, which is capable of presenting single content formed by combining content materials such as stored video data, audio data, and/or HTML document data. This conventional system allows the combined content materials to be synchronously displayed according to a predetermined scenario, achieving more
10 widely various representations, compared with conventionally formed content.

Under these circumstances, a technique of multicasting live audio and video data, or real-time multimedia data, to a plurality of participants has received widespread attention,
15 and therefore various multimedia content multicasting techniques have been proposed (for example, see US Patent No. US 6,351,467 B1).

On the other hand, a live-video transmission system which transmits live video data from a transmitter to a receiver has
20 been described in Japanese Patent Application Unexamined Publication No. P2001-45445A. More specifically, this live-video transmission system attaches picture ID and indexes to the live video data, allowing a user to select desired pictures of the live content. This conventional live-video transmission
25 system is based on the unicast technology.

In the multicast delivery of real-time content streams,

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however, time-shifting operations of the real-time content,
including pause, reverse, fast-forward, and time-shift
replaying during recording, are not possible. In other words,
it is impossible to play back awhile-preceding live video

5   pictures. Taking an electronic conference using
the multicasting technology as an example, when a participant
is late for the electronic conference, the participant cannot
reference previous presentation documents and therefore may not
understand well a discussion that is currently made in the

10   electronic conference.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a system
and method for delivering real-time data streams allowing
time-shifting operations such as pause, reverse, fast-forward,

15   and time-shift replaying.

According to the present invention, a transmitter delivers
real-time multimedia data in multicast to the receivers while
storing the real-time multimedia data into a first memory. When
having received a time shift transition command from a receiver,

20   the transmitter reads time-shifted multimedia data from the
first memory depending on the time-shift transition command.
The time-shifted multimedia data is then transmitted in unicast
to the receiver which originated the time-shift transition

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command. The receiver receives the real-time multimedia data
in multicast from the transmitter before transmitting the
time-shift transition command and receives the
time-shifted multimedia data in unicast from the transmitter

5   after transmitting the time-shift transition command.

The transmitter preferably adds a time stamp to each
transmission block size of the real-time multimedia data, stores
the real-time multimedia data with time stamps into the
first memory, and delivers the real-time multimedia data with

10   time stamps to the receivers.

The receiver preferably creates a thumbnail picture from
the real-time multimedia data received from the transmitter
each time an amount of real-time multimedia data per unit time
exceeds a predetermined level, and stores thumbnail pictures

15   with corresponding time stamps into a second memory so as to
designate a desired thumbnail picture, allowing a desired
location of the real-time multimedia data to be designated.
In addition, when a time-shift request occurs, the receiver
creates a time-shift transition command based on the thumbnail

20   pictures with the corresponding time stamps stored in the
second memory, and transmits the time-shift transition command
to the transmitter so as to receive time-shifted multimedia
data from the transmitter in unicast.

The time-shift transition command may be one of a replay

25   start location designation command, a pause command, a reverse
command, a slow-replay command, and a fast-forward command.

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According to another embodiment, each of the receivers stores the real-time multimedia data received from the transmitter into a third memory and, when a time-shift request occurs, reads time-shifted multimedia data from the third memory
5   depending on the time-shift request.

According to another aspect of the present invention, when having received a start request command from a receiver, the transmitter delivers real-time multimedia data in multicast to the receiver while storing the real-time multimedia data
10 into a first memory. When having received a time-shift transition command from the receiver, the transmitter reads time-shifted multimedia data from the first memory depending on the time-shift transition command, to transmit the time-shifted multimedia data in unicast to the receiver which
15 originated the time-shift transition command. When having received a termination request command from the receiver, the transmitter terminates multimedia data delivery to the receiver.

The transmitter may include: an input section for
20 inputting real-time multimedia data; a multicast transmitter for transmitting the real-time multimedia data to each of the receivers; a first unicast transceiver for receiving a command from a receiver and transmitting a response to the receiver; a command analyzer for analyzing a command received from the
25 receiver to determine a type of the received command; a first memory for storing the real-time multimedia data; and

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a first controller controlling the multicast transmitter, the
unicast transceiver and the first memory, such that the
real time multimedia data is delivered in multicast to each
of the receivers while storing the real-time multimedia data
5   into the first memory, wherein, when having received a time-shift
transition command from a receiver, time-shifted multimedia
data is read from the first memory depending on the time-shift
transition command and is transmitted in unicast to the receiver
which originated the time-shift transition command.

10   The receiver may include: a multicast receiver for
receiving the real-time multimedia data from the transmitter;
a second unicast transceiver for transmitting a command to the
transmitter and receiving a response to the command from the
transmitter; and a second controller controlling such that the
15   real-time multimedia data is received in multicast from the
transmitter before transmitting the time-shift transition
command, and the time-shifted multimedia data is received in
unicast from the transmitter after transmitting the time-shift
transition command.

20   As described above, the real-time multimedia stream
delivery system according to the present invention is provided
with a multicast-unicast changeover mechanism for changing
between real-time multimedia data delivery and
time-shifted multimedia data delivery, which allows
25   time-shifted replay in real-time multimedia streaming delivery.
In other words, the real-time multimedia data is transmitted

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in multicast and the time-shifted multimedia data is transmitted
on demand to a receiver in unicast. Accordingly, each receiver
having relatively small amount of memory capacity can provide
time-shifted replay without storing real-time multimedia data.

5   Further, when the receiver creates thumbnail pictures
from the received real-time multimedia data, time stamps
attached to the thumbnail pictures are stored into the storage
device. Accordingly, by just designating and sending a desired
thumbnail picture to the transmitter, a user-desired scene of
10   real-time multimedia data can be easily replayed.

                    BRIEF DESCRIPTION OF THE DRAWINGS

        Fig. 1 is a block diagram showing a real-time stream
delivery system according to a first embodiment of the present
invention;

15   Fig. 2 is a block diagram showing a functional structure
of a controller in the real-time stream delivery system according
to the first embodiment;

        Fig. 3 is a flow chart showing a transmission control
operation of a transmitter in the real-time stream delivery
20   system according to the first embodiment;

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Fig. 4 is a flow chart showing a reception control operation of a receiver in the real-time stream delivery system according to the first embodiment;

Fig. 5 is a diagram showing a UDP format used in multicast transmission;

Fig. 6 is a diagram showing a TCP format used in unicast transmission;

Fig. 7 is a diagram showing the format of a command;

Fig. 8 is a diagram showing the time-varying amount of multimedia data for explanation of creating thumbnail images in the first embodiment;

Fig. 9 is a diagram showing a sequence of communication when a start request command is sent from the receiver to the transmitter in the first embodiment;

Fig. 10 is a diagram showing a sequence of communication when a time-shift transition command is sent from the receiver to the transmitter in the first embodiment;

Fig. 11 is a diagram showing a sequence of communication when a termination request command is sent from the receiver

to the transmitter in the first embodiment;

Fig. 12 is a block diagram showing a real-time stream delivery system according to a second embodiment of the present invention; and

5   Fig. 13 is a block diagram showing a real-time stream delivery system according to a third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in Fig. 1, it is assumed for simplicity that
10   a delivery system of real-time multimedia streams according to a first embodiment of the present invention is composed of a transmitter 10 and a receiver 12, which are connected by a network 11. Needless to say, a plurality of receivers 12 may be connected to the network 11. The network 11 may be a
15   communication network such as the Internet or Intranet. As described later, the transmitter 10 delivers real-time multimedia data such as live video data to the receiver(s) 12 in multicast through the network. When a time-shift replaying request occurs, the transmitter 10
20   delivers requested time-shifted multimedia data in unicast through the network 11 to the receiver 12 which originates that

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request. The detailed structures and operations of the
transmitter 10 and the receiver 12 will be described hereinafter.
Transmitter

In the transmitter 10, an input section 101 inputs
5   real-time multimedia data including still pictures, moving
pictures, audio data, and/or text data from an input device
such as still/video camera, microphone and the likes. Here,
the multimedia data may be digital or analog.

A data processing section 102 receives the multimedia
10   data from the input section 101 and performs data processing
such as analog-to-digital conversion, format transform, and
time stamp addition. The time stamp addition is to add time
information (time stamp) to the multimedia data for each packet
size. The multimedia data with time stamps added for each packet
15   size are output to a controller 104 and stored in a storage
device 103, which may be a memory device such as a hard disk
drive (HDD).

The controller 104 inputs the output of the data processing
section 102 and the output of the storage device 103 and selects
20   one of these outputs depending on a command analytical result
inputted from a command analyzer 105. The command analyzer
105 analyzes a command received by a command receiver 108 to
output its analytical result to the controller 104 and a command
response section 107. Depending on the analytical result, the
25   controller 104 selects one of the output of the data processing
section 102 and the output of the storage device 103 to output

selected multimedia data with time stamps to a transmission data processor 106. Detailed structure and operation of the controller 104 will be described later.

The transmission data processor 106 assembles data packets
5 from the multimedia data with time stamps and, if necessary, encrypts the payloads thereof. The data packets are outputted to a selected one of a multicast transmitter 111 and a unicast transmitter 112 of a transmission section 109.

The command response section 107 creates a command
10 response packet according to the analytical result inputted from the command analyzer 105 and outputs it to the unicast transmitter 112.

The command receiver 108 receives a command packet from a certain receiver 12 through a unicast receiver 113 of a
15 reception section 110 and outputs its command to the command analyzer 105. In this embodiment, a multicast receiver 114 of the reception section 110 is not used.

Receiver

In the receiver 12, the receiver 12 is provided with a
20 reception section 115 including a multicast receiver 117 and a unicast receiver 118 and a transmission section 116 including a unicast transmitter 119 and a multicast transmitter 120. The multicast receiver 117 receives real-time multimedia data from the multicast transmitter 111 of the transmitter 10. The
25 unicast receiver 118 receives time-shifted multimedia data or time-shift control data from the unicast transmitter 112 of

the transmitter 10. In this embodiment, the multicast transmitter 120 is not used.

A received data analyzer 121 analyzes packets received from the transmitter 10 through the unicast receiver 118 to

5   determine whether a received packet is a data packet or a command response packet. When the data packet is received, the received data analyzer 121 outputs it as time-shifted multimedia data to a data reception selector 123. When the command response packet is received, the received data analyzer 121 outputs it

10 to a controller 124.

A command transmitter 122 inputs a command from the controller 124 to assemble a command packet. The command packet is outputted to the transmitter 10 through the unicast transmitter 119.

15 The data reception selector 123 selects one of the real-time multimedia data received from the multicast receiver 117 and the time-shifted multimedia data received from the received data analyzer 121 depending on an instruction inputted from the controller 124. A selected multimedia data is

20 outputted to a reception data processor 125.

The controller 124 issues a command to a command transmitter 122, instructs the data reception selector 123 to perform received data selection as described above, and controls reception flag (TRUE/FALSE) and reception mode

25 (real-time/time-shift) as described later.

The reception data processor 125 performs digital-to

analog conversion and format transform of received multimedia
data, analyzes the received multimedia data and its attached
time stamps, and creates thumbnail pictures depending on the
amount of multimedia data per unit time, which will be described
5   later.

A storage device 126 stores thumbnail pictures created
by the reception data processor 125 together with time stamps.
The storage device 126 may be a memory device such as a hard
disk drive (HDD). An output section 127 inputs multimedia data
10   from the reception data processor 125 and the thumbnail pictures
from the storage device 126 and outputs and, as necessary,
combines them to an external monitor (not shown).

Multicast and Unicast

Multicast transmission and Unicast transmission are
15   defined as standards in RFC (Request For Comments) issued by
IETF (Internet Engineering Task Force).

Multicast transmission is defined in RFC 768: User Datagram
Protocol (UDP), in which UDP is used to transfer data. UDP
has a relatively simple format composed of: Source/Destination
20   IP address fields; Protocol field (here, protocol number "17"
is assigned), Packet length field; and Data field (see Fig.
5).

Unicast transmission is defined in RFC793: Transmission
Control Protocol (TCP), in which TCP is used to transfer data.
25   TCP has a format composed of Source port field, Destination
port field, Sequence number field (indicating the location of

transmitted data), Acknowledgement number field (indicating

the sequence number of next data to be transmitted), Data offset

field (indicating the start location of data), Reserved field,

Control flag field, Window field (indicating the window size),

5   Checksum field, Urgent pointer field, Options field, Padding

field, and Data field (see Fig. 6). In Control flag field,

URG flag set to 1 indicates that the data field includes urgent

data, ACK flag set to 1 indicates that the acknowledgement field

is valid (ACK flag is normally set to 1 other than connection

10   establishment), PSH (Push) flag set to 1 indicates that buffering

is not performed, RST (Reset) flag set to 1 indicates that a

connection is forced to be disconnected, SYN (Synchronize) flag

set to 1 indicates that a connection tries to be established,

and FIN (Finish flag set to 1 indicates that the connection

15   tries to be disconnected. The urgent pointer field indicates

the length of urgent data included in data when URG flag is

set to 1.

Commands

       A command is composed of a command field and an option

20   field as shown in Fig. 7. The command field defines a command

depending on what value is written therein. For example, a

101 value indicates Replay command, a 103 indicates Pause command,

a 104 indicates Fast-Forward command, a 105 indicates Reverse

command, and a 106 indicates Thumbnail-based Replay Start

25   Location Designation command.

       The option field defines the following options for each

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command defined in the command field. In the case of Replay command, replay speed (normal or slow) and current time stamp are defined in the option field. In the case of Pause command, current time stamp is defined. In the case of Fast-Forward

5 command, fast-forward speed with replaying or not and current time stamp are defined. In the case of Reverse command, reverse speed with replaying or not and current time stamp are defined. In the case of Thumbnail-based Replay Start Location Designation command, the designated time stamp is set in the option field.

10   The command field and the option field as described above allow both real-time replay and time-shift replay.

Controller of Transmitter

        As shown in Fig. 2, the controller 104 of the transmitter 10 implements a database 104a, a device status manager 104b,

15 and a data selector 104c. The database 104a stores a record composed of device information, transmission flag, transmission mode, and time stamp for each receiver 12. The device status manager 104b receives an analytic result from the command analyzer 105 to store as a record the device

20 information identifying the receiver 12 that has transmitted a corresponding command and the delivery information composed of transmission flag, transmission mode, and time stamp. The device information identifies the receiver 12, which may be IP (Internet Protocol) address. The transmission mode includes

25 "real-time", "time-shift" and "not defined". The transmission flag is one of TRUE and FALSE. The device information and the

time stamp are extracted from a received command by the command analyzer 105.

The data selector 104c selects one of the real-time multimedia data received from the data processing section 102 and the time-shifted multimedia data received from the storage device 103 depending on the device information and the delivery information stored in the database 104a.

In the case where a start request command for real-time multimedia delivery has been received from the receiver 12, the device status manager 104b searches the database 104a for the device information included in the received start request command. In this case, since no device information identifying the receiver 12 is found, the device status manager 104b registers a new record for the receiver 12 into the database 104a. For example, the device information is set to the IP address of the receiver 12, the transmission flag is set to TRUE, the transmission mode is set to "real-time", and the time stamp is set to 1000.

The data selector 104c monitors the database 104a at all times and, when no change in device status of the receiver 12 occurs in the database 104a, selects the real-time multimedia data received from the data processing section 102 to output it to the transmission data processor 106.

Thereafter, when a time-shift transition command has been received from the receiver 12, the device status manager 104b searches the database 104a for the device information included

in the received time-shift transition command. In this case,
since the device information identifying the receiver 12 is
found, the device status manager 104b sets the transmission mode
of the record corresponding to the receiver 12 to "time-shift"
5   and similarly sets the time stamp thereof to the shifted time
stamp. When the transmission mode has been changed in the
database 104a, the data selector 104c detects such a change
and therefore selects the time-shifted multimedia data received
from the storage device 103 to output it to the transmission
10 data processor 106.

When a termination command has been received from the
receiver 12, the device status manager 104b searches the database
104a for the device information included in the received
termination command. In this case, since the device information
15 identifying the receiver 12 is found, the device status manager
104b sets the transmission flag of the record corresponding
to the receiver 12 to "FALSE". When the data selector 104c
detects such a change, the data selector 104c stops delivery
of real-time or time-shifted multimedia stream.

20   It should be noted that the controller 104 may be composed
of a program-controlled processor implementing the data
selector 104c and the device status manager 104b and a memory
(not shown) separately implementing the database 104a.

Detailed control operations of the transmitter 10 and
25 the receiver 12 will be described hereafter.

Operation of Transmitter

Referring to Fig. 3, the controller 104 first performs
initialization of the database 104a such that the transmission
flag is set to "FALSE" and the transmission mode to "real-time"
(step A1). Thereafter, it is determined whether the command
5   receiver 108 receives a command packet from a receiver 12 through
the unicast receiver 113 (step A2). When no command has been
received (No in step A2), it is further determined whether the
transmission flag of the database 104a is "TRUE" (step A18).
When the transmission flag is not "TRUE" (No in step A18), it means
10 that neither real-time nor time-shifted multimedia data is
delivered and therefore control goes back to the step A2.

When the transmission flag is "TRUE" (Yes in step A18),
it means that real-time/time-shifted multimedia data is
delivered to the receiver 12 identified by the device information
15 corresponding to the transmission flag of TRUE and therefore
the control goes to step A12, which will be described later.

When a command has been received (Yes in step A2), the
command analyzer 105 analyzes the received command and the
controller 104 performs delivery control depending on the
20 command analytic result (steps A3-A11).

More specifically, when the received command is a start
request command (Yes in step A3), the command analyzer 105
instructs the command response section 107 to acknowledge
receipt of the start request command (step A4). The command
25 response section 107 transmits a response to the start request
command to the receiver 12 through the unicast transmitter 112.

Thereafter, the device status manager 104b of the controller 104 registers device information of the receiver 12 and writes corresponding delivery information into the database 104a such that its transmission flag is set to "TRUE" (step A5) and its

5   transmission mode is set to "real-time" (step A6).

When the received command is not a start request command (No in step A3) but a termination request command (Yes in step A7), the command analyzer 105 instructs the command response section 107 to acknowledge receipt of the termination request

10   command (step A19). The command response section 107 transmits a response to the termination request command to the receiver 12 through the unicast transmitter 112. Thereafter, the device status manager 104b of the controller 104 writes the corresponding delivery information into the database 104a such

15   that its transmission flag is reset to "FALSE" (step A20) and then the transmission process is terminated (step A21).

When the received command is neither a start request command (No in step A3) nor a termination request command (No in step A7) but a time-shift transition command (Yes in step

20   A8), the command analyzer 105 instructs the command response section 107 to acknowledge receipt of the time-shift transition command (step A9). The command response section 107 transmits a response to the time-shift transition command to the receiver 12 through the unicast transmitter 112. Thereafter, the device

25   status manager 104b of the controller 104 writes corresponding delivery information into the database 104a such that its

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transmission mode is set to "time-shift" (step A10) and its

time stamp is set to its designated value (step A11). Such

a time shift transition command includes a thumbnail-based

replay start location designation command, a pause command,

5   a reverse command, a slow-replay command, or a fast-forward

command. Hereinafter, it is assumed that a time shift

transition command is a thumbnail-based replay start location

designation command.

Subsequently, it is determined whether the current

10 transmission mode of the corresponding receiver 12 indicates

"real-time" (step A12). When it indicates "real-time" (Yes

in step A12), the data selector 104c of the controller 104

receives real-time multimedia data from the data processing

section 102 (step A14) and transfers it to the transmission

15 data processor 106. The transmission data processor 106

assembles data packets from the real-time multimedia data with

time stamps, and outputs them to the multicast transmitter 111

of the transmission section 109. In this way, the

real time multimedia data is transmitted to the receiver 12

20 (step A15) and then the control goes back to the step A2.

In the case where the start request command is received

after live performance or conference has started, the controller

104 preferably attaches preceding thumbnail pictures to the

real-time multimedia data to be transmitted.

25   When the current transmission mode of the corresponding

receiver 12 indicates "time-shift" (No in step A12), the

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controller 104 checks the presence or absence of data stored
in the storage device 103 (step A13). When no
time-shifted multimedia data is left in the storage device 103
(Yes in step A13), the data selector 104c of the controller
5   104 receives real-time multimedia data from the data processing
section 102 (step A14) and transfers it to the transmission
data processor 106. The transmission data processor 106
assembles data packets from the real-time multimedia data with
time stamps, and outputs them to the multicast transmitter 111
10 of the transmission section 109. In this way, the
real-time multimedia data is transmitted to the receiver 12
(step A15) and then the control goes back to the step A2. As
described before, when the real-time multimedia data is
transmitted after live performance or conference has started,
15 the controller 104 preferably attaches preceding thumbnail
pictures to the real-time multimedia data to be transmitted.

When time-shifted multimedia data is left in the storage
device 103 (No in step A13), the data selector 104c of the
controller 104 receives time-shifted multimedia data from the
20 storage device 103 based on a time stamp value set in the database
104a corresponding to the receiver 12 (step A16) and transfers
it to the transmission data processor 106. The transmission
data processor 106 assembles unicast data packets from the
time-shifted multimedia data with time-shifted time stamps and
25 real-time time stamps, and outputs them to the unicast
transmitter 112 of the transmission section 109. In this way,

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the time-shifted multimedia data is transmitted to the receiver
12 (step A17) and then the control goes back to the step A2.

Assuming that a time-shift transition command is a reverse
command, at the step A11, the device status manager 104b of
5   the controller 104 writes a current time stamp and a reverse
interval received from the receiver 12 into the database 104a.
At the step A16, the data selector 104c of the controller 104
fetches time-shifted multimedia data from the storage device
103 based on time stamp values sequentially calculated from
10 the current time stamp and the reverse interval and outputs
them to the transmission data processor 106. More specifically,
the time stamp values are calculated by sequentially subtracting
the reverse interval from the current time stamp. For example,
assuming that the current time stamp is 100 and the reverse
15 interval is 5, the data selector 104b sequentially fetches
time-shifted multimedia data each corresponding to time stamps
of 100, 95, 90, and so on from the storage device 103 at regular
intervals (e.g. 1).

Assuming that a time-shift transition command is a
20 slow-replay command, at the step A11, the device status manager
104b of the controller 104 writes a current time stamp and a
slow replay interval received from the receiver 12 into the
database 104a. At the step A16, the data selector 104c of the
controller 104 fetches time-shifted multimedia data from the
25 storage device 103 based on time stamp values calculated from
the current time stamp and the slow-replay interval and outputs

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them to the transmission data processor 106. More specifically,
the time stamp values are calculated by sequentially adding
the slow-replay interval to the current time stamp. For example,
assuming that the current time stamp is 100 and the slow-replay
5   interval is 0.1, the data selector 104b sequentially fetches
time-shifted multimedia data each corresponding to time stamps
of 100, 100.1, 100.2 and so on from the storage device 103 at
regular intervals (e.g. 1).

Assuming that a time-shift transition command is a
10   fast-forward replay command, at the step A11, the device
status manager 104b of the controller 104 writes a current time
stamp and a fast-forward interval received from the receiver
12 into the database 104a. At the step A16, the data selector
104c of the controller 104 fetches time-shifted multimedia data
15   from the storage device 103 based on time stamp values calculated
from the current time stamp and the fast-forward interval and
outputs them to the transmission data processor 106. More
specifically, the time stamp values are calculated by
sequentially adding the fast-forward interval to the current
20   time stamp. For example, assuming that the current time stamp
is 100 and the fast-forward interval is 5, the data selector
104b sequentially fetches time-shifted multimedia data each
corresponding to time stamps of 100, 105, 110 and so on from
the storage device 103 at regular intervals (e.g. 1).

25   Assuming that a time-shift transition command is a pause
command, at the step A11, the device status manager 104b of

the controller 104 writes a current time stamp into the database 104a. At the step A16, the data selector 104c of the controller 104 fetches time-shifted multimedia data from the storage device 103 based on a time stamp value calculated from the current

5   time stamp and outputs it to the transmission data processor 106. For example, assuming that the current time stamp is 100, the data selector 104b sequentially fetches time-shifted multimedia data corresponding to the time stamp of 100 from the storage device 103 at regular intervals (e.g.

10 1). When a pause release command has been received together with a current time stamp from the receiver 12, the controller 104 sequentially receives the following time-shifted multimedia data from the storage device 103 to transmit them to the receiver 12.

15 Operation of Receiver

        Referring to Fig. 4, the controller 124 first performs initialization such that the reception flag is set to "FALSE" and the reception mode to "real-time" (step B1). Thereafter, the controller 124 determines whether a command transmission

20 request is received from outside user (step B2). When a command transmission request has been received (Yes in step B2), the controller 124 instructs the command transmitter 122 to transmit a requested command to the transmitter 10 through the unicast transmitter 110 of the transmission section 116 (step B3). Such

25 a requested command may be a start request command, a thumbnail-based replay start location designation command, a

pause command, a reverse command, a fast-forward command, a slow-replay command, a termination request command or the likes.

Thereafter, it is determined whether the received data analyzer 121 receives a command response at the unicast receiver

5   118 (step B4). When no command response has been received (No in step B4), it is further determined whether the reception flag is "TRUE" (step B18). When the reception flag is not "TRUE" (No in step B18), it means that neither real-time nor time-shifted multimedia data is received and therefore control

10 goes back to the step B2.

When the reception flag is "TRUE" (Yes in step B18), it means that real-time/time-shifted multimedia data is received and therefore the control goes to step B11, which will be described later.

15   When a command response has been received (Yes in step B4), the received data analyzer 121 analyzes the received command response to determined whether it is a response to the start request command (step B5). When it is not a response to the start request command (No in step B5), the control goes to a

20 step B8. When it is a response to the start request command (Yes in step B5), the controller 124 sets the reception flag to "TRUE" (step B6) and the reception mode to "real-time" (step B7).

Thereafter, the received data analyzer 121 determines

25 whether the received command response is a response to the termination request command (step B8). When the received

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command is a response to the termination request command (Yes in step B8), the controller 124 sets the reception flag to "FALSE" (step B19) and terminates the process (step B20).

When the received command response is not a response to
5 the termination request command (No in step B8), the received data analyzer 121 determines whether the received command response is a response to the time-shift transition command (step B9). When it is the response to the time-shift transition command (Yes in step B9), the controller 124 sets the
10 reception mode to "time-shift" (step B10).

Subsequently, it is determined whether the current reception mode indicates "real-time" (step B11). When it indicates "real-time" (Yes in step B11), the data reception selector 123 selects real-time multimedia data received from
15 the multicast receiver 117 of the reception section 115 (step B15) and transfers it to the reception data processor 125.

The reception data processor 125, as necessary, performs thumbnail creation (step B16) before back to the step B2. In the step B16, the reception data processor 125 monitors the
20 amount of received real-time multimedia data and, when the amount of received data per unit time exceeds a predetermined threshold, creates thumbnail pictures from the received real-time multimedia data to store the thumbnail pictures with time stamps into the storage device 126.

25 When the current reception mode indicates "time-shift" (No in step B11), the data reception selector 123 gets a real-time

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time stamp of real-time multimedia data and a time-shifted time

stamp of the time-shifted multimedia data attached to the

real-time multimedia data (step B12). Thereafter, the data

reception selector 123 determines whether a difference between

5   the time-shifted time stamp and the real-time time stamp is

smaller than a predetermined threshold, to decide on whether

a time-shifted picture catches up the real-time picture (step

B13).

When a time-shifted picture catches up the real-time

10   picture (Yes in step B13), the controller 124 sets the

reception mode to "real-time" (step B14). The data reception

selector 123 selects real-time multimedia data received from

the multicast receiver 117 of the reception section 115 (step

B15) and transfers it to the reception data processor 125. The

15   reception data processor 125 performs thumbnail creation (step

B16) before back to the step B2. When a time-shifted picture

does not catch up the real-time picture (No in step B13), the

data reception selector 123 selects time-shifted multimedia

data received from the received data analyzer 121 (step B17)

20   and then the control goes back to the step B2.

Taking a teleconference as an example, a presenter may

use an electronic version of presentation documents to provide

an explanation to conferees. In the teleconference application,

there is seldom a case where an entire picture is changed during

25   explanation of a single page. Accordingly, there is frequently

used a delivery method such that difference data between a

current frame and an immediately preceding frame or a
several-second-old frame is delivered to reduce the load on
the network as much as possible. In such a case, when breaking
across pages, a picture is changed and thereby the amount of

5   real-time multimedia data is increased as shown in Fig. 8.
Therefore, the receiver 12 can easily detect page turning. At
such page change timing, it is possible to create thumbnail
pictures from the real-time multimedia data, by which the
conferees can obtain an electronic version of presentation

10   documents as the thumbnail pictures and further use the time
stamps of the thumbnail pictures as indexes to designate replay
start locations of the real-time multimedia data. Accordingly,
when the present invention is applied to the teleconference
application, it is possible for a conferee attending to the

15   conference to check subjects on the agenda from the beginning
of the conference. Further, when a conferee leaves the
conference for a while, the conferee can check subjects on the
agenda when the conferee is absent. Furthermore, a conferee
can look at the foregoing several pages of the presentation

20   documents delivered during the conference.

Sequential Operations

Sequential operations between the transmitter 10 and the
receiver 12 will be described with reference to Figs. 9-11.

As shown in Fig. 9, when a start request command has been

25   sent from the receiver 12 to the transmitter 10, the transmitter
10 sends a response to the start request command back to the

receiver 12 and sets the transmission mode to "real-time". At
the receiver 12, when having received the response to the start
request command, the reception mode is set to "real-time." In
the transmitter 10, the controller 104 receives

5   real-time multimedia data from the data processing section 102
and sends it to the receiver 12 in multicast.

As shown in Fig. 10, when a slow-replaying request command
has been sent from the receiver 12 to the transmitter 10, the
transmitter 10 sends a response to the slow-replaying request

10   command back to the receiver 12 and sets the transmission mode
to "time-shift". In the transmitter 10, the controller 104
receives time-shifted multimedia data from the storage device
103 and sends it to the receiver 12 in unicast.

As shown in Fig. 11, when a termination request command

15   has been sent from the receiver 12 to the transmitter 10, the
transmitter 10 sends a response to the termination request
command back to the receiver 12 and terminates the transmission
process.

Advantages

20   As described above, the real-time multimedia stream
delivery system according to the first embodiment of the present
invention is provided with a multicast unicast
changeover mechanism for changing between real-time multimedia
data delivery and time-shifted multimedia data delivery, which

25   allows time-shifted replay in real-time multimedia streaming
delivery.

Further, when the receiver creates thumbnail pictures
from the received real-time multimedia data, time stamps
attached to the thumbnail pictures are stored into the storage
device. Accordingly, by sending a desired time stamp to the
5   transmitter, a desired replay start location of
real time multimedia data can be easily designated.

Referring to Fig. 12, a real-time multimedia stream
delivery system according to a second embodiment of the present
invention is composed of a transmitter 10 and a receiver 13,
10 which are connected by a network 11. Needless to say, a plurality
of receivers 13 may be connected to the network 11. Blocks
similar to those previously described with reference to Fig.
1 are denoted by the same reference numerals and detailed
descriptions thereof will be omitted.

15   As described in the first embodiment, the transmitter
10 delivers real-time multimedia data to the receiver(s) 13
in multicast through the network 11. When a time-shift
replaying request occurs, the transmitter 10 delivers requested
time-shifted multimedia data in unicast through the network
20 11 to the receiver 13 which originates that request.

According to the second embodiment, in addition, a storage
device 130 of each receiver 13 is provided to store
real-time multimedia data received from the transmitter 10
in multicast, which can be used for time-shift replaying under
25 control of the controller 128. More specifically, a controller

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128 of the receiver 13 instructs a reception data processor
129 to store the received real-time multimedia data into the
storage device 130. Depending on user's instruction, the
controller 128 can select one of an inside replay mode and an
5   outside replay mode. The outside replay mode is that time-shift
replaying is performed at the transmitter 10 as described in
the first embodiment. The inside replay mode is that time-shift
replaying is performed at the receiver 13 by reading
time-shifted multimedia data from the storage device 130. The
10   time-shifted multimedia data is designated by inputting a
time-shift transition command similar to the first embodiment.

     In order to store the necessary amount of
real-time multimedia data received from the transmitter 10,
the storage device 130 needs sufficient capacity, which may
15   be implemented by hard disk drive (HDD). Further, the reception
data processor 129 has functions of storing real-time multimedia
data into the storage device 130 and instructing the storage
device 130 to output time-shifted multimedia data to the output
section 127 under the control of the controller 128.

20   As described above, according to the second embodiment,
the inside and outside replay modes can be selected at a receiver.
Since the inside replay mode allows time-shifting replay without
transferring multimedia data through the network 11, the load
on the network 11 can be dramatically reduced.

25   The above-described functions of the transmitter 10 may

be implemented by transmitter control programs running on a program-controlled processor. Similarly, the above-described functions of the receiver 12 or 13 may be implemented by receiver control programs running on a program-controlled processor.

5   As shown in Fig. 13, the data processing section 102, the controller 104, the command analyzer 105, transmission data processor 106, the command response section 107, and the command receiver 108 may be implemented by transmission control programs stored in a memory 202 running on a program-controlled processor

10   201. Similarly, the received data analyzer 121, the command transmitter 122, data reception selector 123, the controller 124/128, and the reception data processor 125/129 may be implemented by reception control programs stored in a memory 204 running on a program-controlled processor 203. The

15   operations of the transmitter 10 and the receiver 12 or 13 are similar to those described with reference to Figs. 3 and 4, and therefore details are omitted.